Forty years of change in aspen forests, Rocky Mountain National Park (CO)

RMNP Beaver Meadows Visitor Center 2015

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Three Questions of Talk

Why are we studying trembling aspen and how is it significant to Colorado forests?

How has aspen dominance in forest stands changed over the last 40 years?

How is aspen responding to the bark beetle epidemic?

Why does aspen matter?

Aspen habitats …

… have excellent properties for **filtering and retaining runoff**.

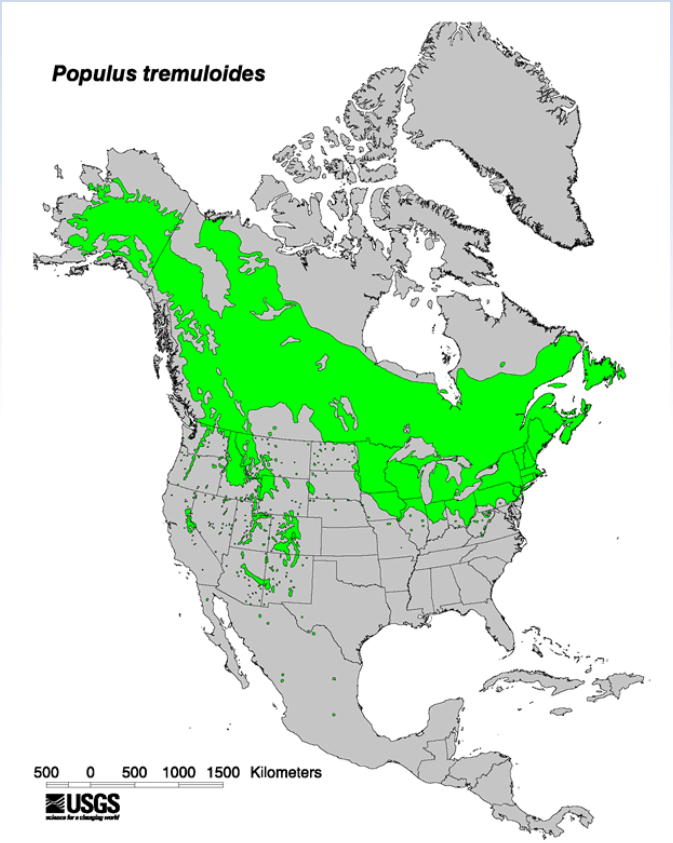
… exhibit a disproportionally **high species richness** compared to other habitat types in the Colorado Front Range.

… provide an essential **food source** for animals.

… are a popular destination for **recreation** activities (“Modern Gold Rush”).

Aspen is Unique

Aspen is the **most widely distributed tree** in North America

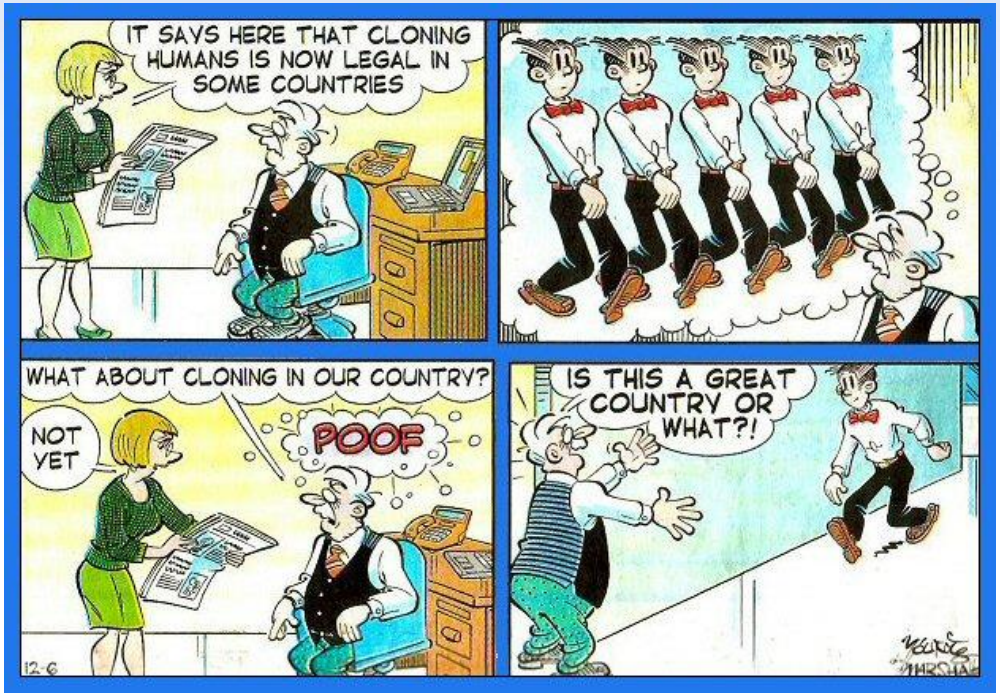


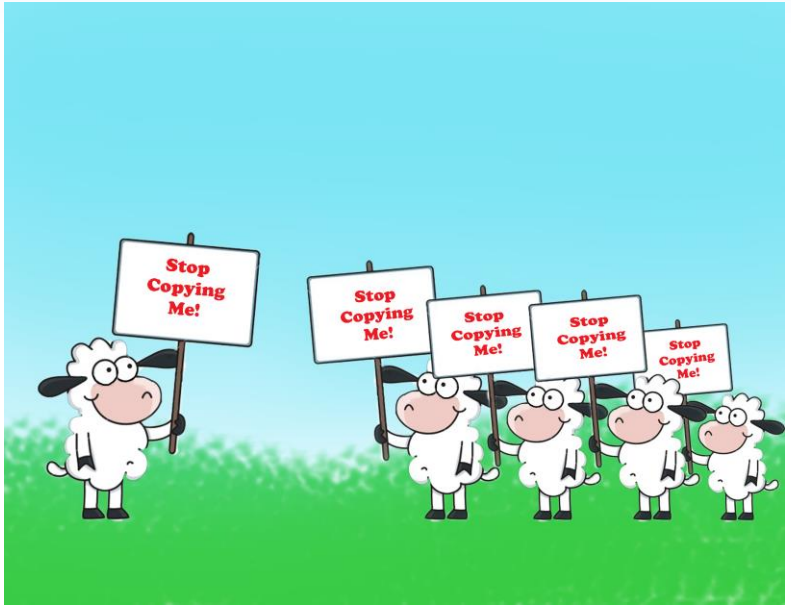
Aspen is **clonal**;

- New stems (ramets) grow from roots
- Clones may be large (thousands of ramets): Pando = 6.6 million kg
- Clones may be old (thousands of years) Pando = 80,000 years old
- Cloning allows for longevity because continual sexual reproduction is not necessary
- Root connections allow exchange of resources from one ramet to another

Aspen is **dioecious** (each clone is either male or female) – for sexual reproduction, two different-sexed individuals must be in the same proximity (pollen is wind-dispersed)

Is it wrong to be clonal?





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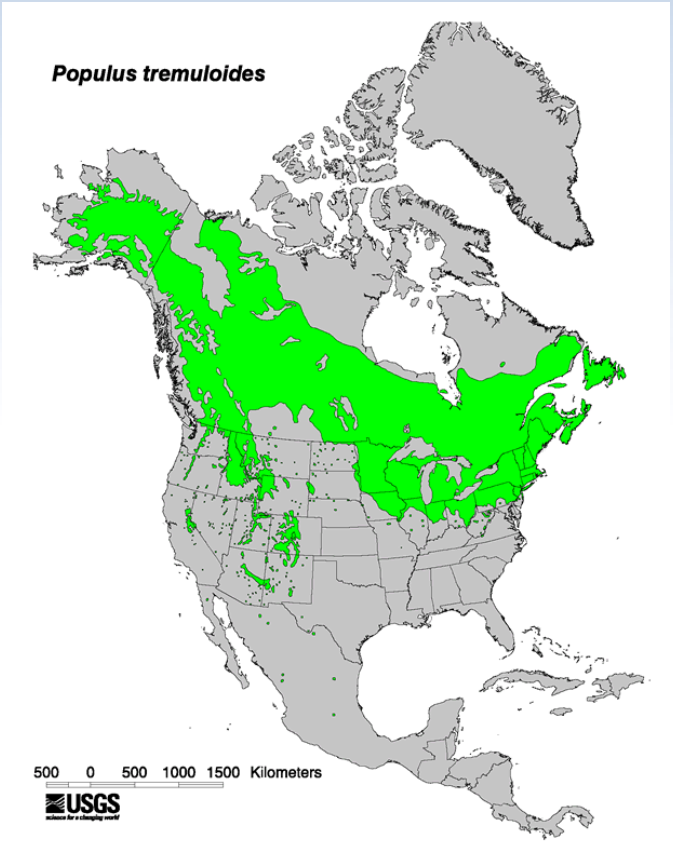

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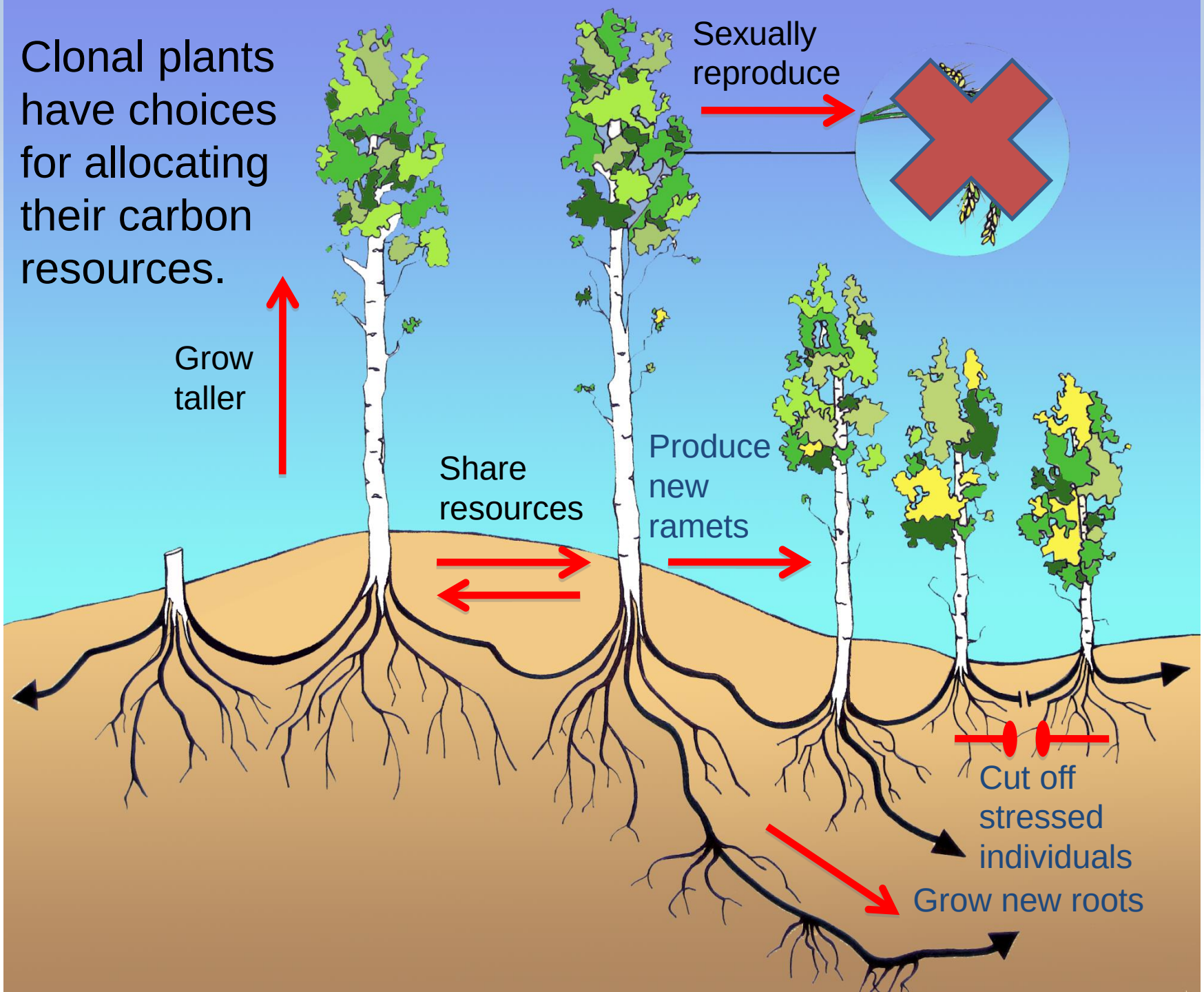
Who is connected to whom and why?

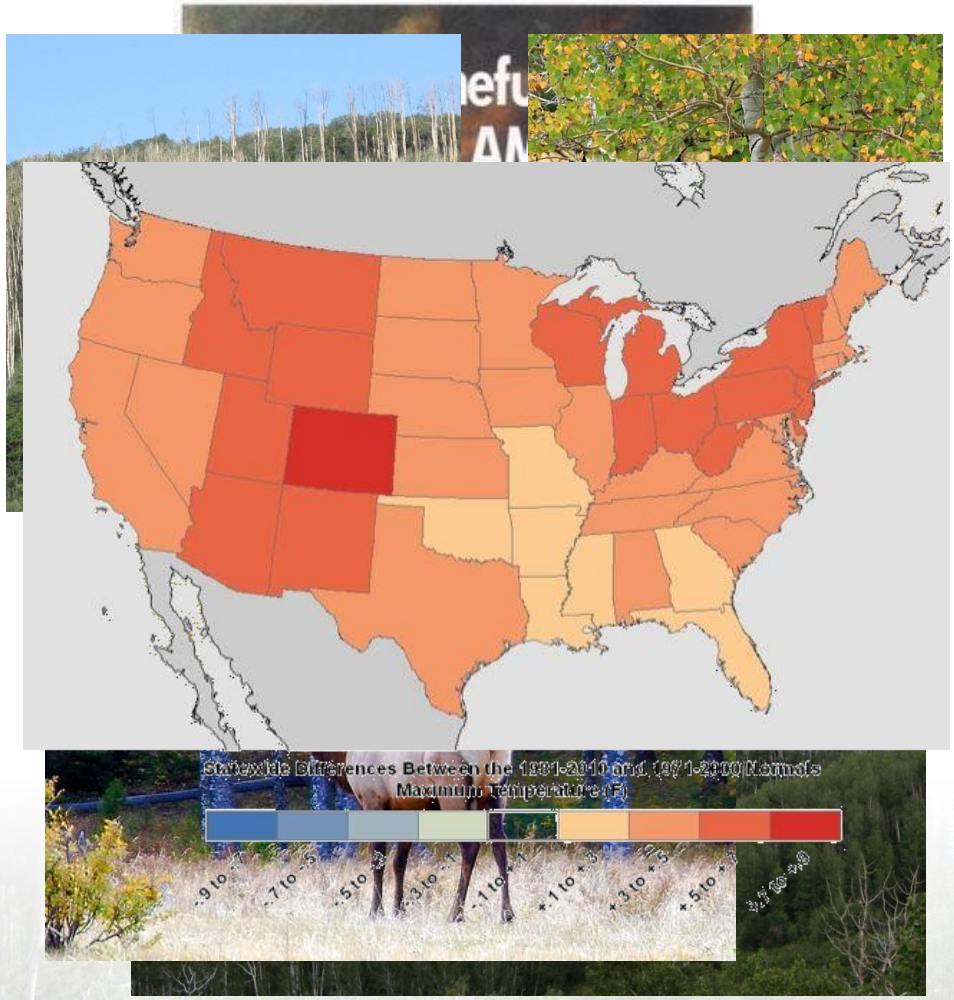

Clonal plants have choices for allocating their carbon resources.
Sexually reproduce
Grow taller
Share resources
Produce new ramets
Cut off stressed individuals
Grow new roots

These characteristics explain why aspen respond so positively to fire. We refer to it as a pioneer species – first onto a site following disturbance.

What is going on?

Aspen stands in the Colorado Rocky Mountains are believed to have been declining over the past 100-150 years.

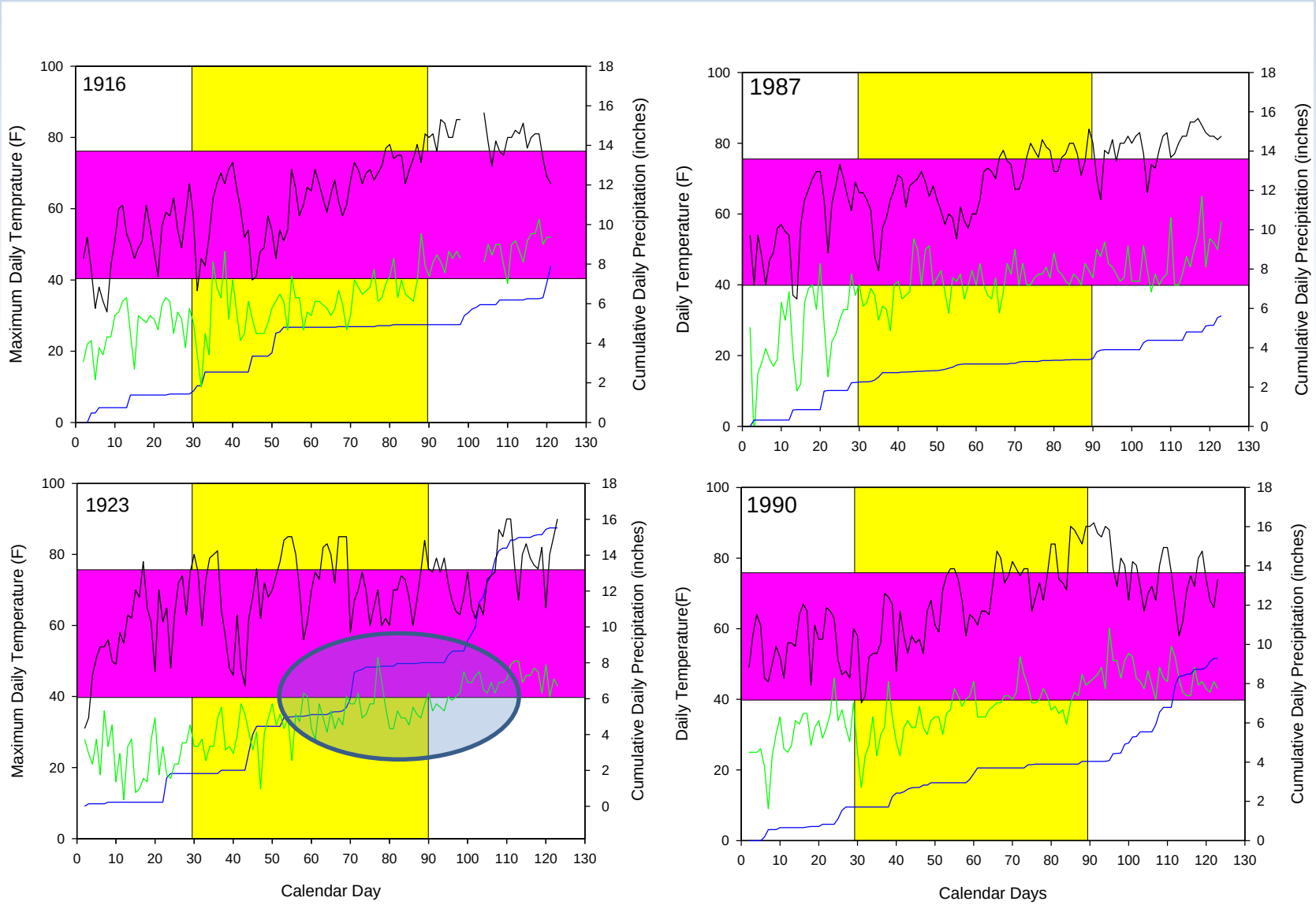
- decades of fire suppression
- Sudden Aspen Decline (SAD)
- increased herbivore population
- **Climate**



Thank goodness for global warming!

Looking at Timing Over Time

Yellow = reproduction window; Pink = seed temperature germination window
The data suggest temperature is not the limiting factor – moisture is.

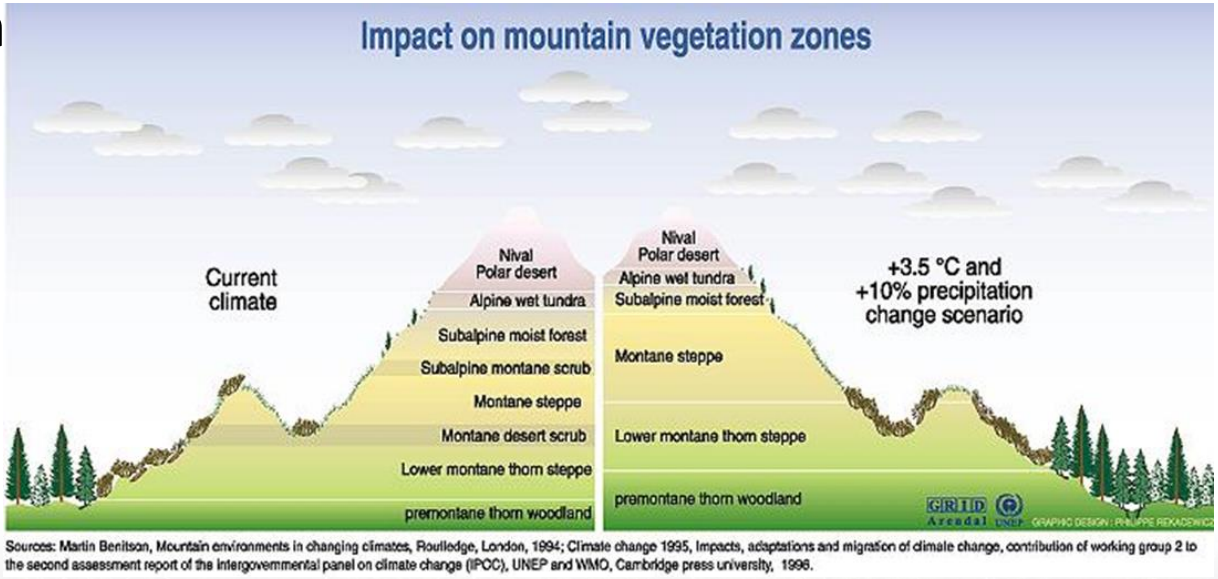


What do we know?

Publication	Location	Range of Study	Aspen Change
Stand Structure and Tree Ring Data			
Romme et al. 1995	Yellowstone National Park, WY	1820-1990	Declining
Ripple & Larsen 2000	Yellowstone National Park, WY	1750-1980	Declining
Romme et al. 2001	San Juan Mountains, CO	1865-2000	Persistent
Hessl & Graumlich 2002	Bridger-Teton National Forest, WY	1830-1897	Persistent
Moore & Huffman 2004	Grand Canyon National Park, NV	18??-20??	Increasing
Kaye et al. 2005	Rocky Mountain National Park, CO	1871-2000	Persistent
Kashian et al. 2007	Northern CO Front Range	1890-2000	Slight decline
Kurzel et al. 2007	Northwestern Colorado	1750-2000	Persistent
Zeigenfuss et al. 2008	Rocky Mountain National Park, CO	1855-1995	Spatially variable
Sankey 2008	Centennial Valley, MT	1850-2000	Persistent
Rogers et al. 2009	Southern Utah	2008	Persistent
Sankey 2012	Reynolds Creek Exp. Watershed, Southwestern ID	1965-2008	Spatially variable
Current Regeneration Used to Assess Long-term Persistence			
Packard 1942	Rocky Mountain National Park, CO	1939-1940	Declining
Baker et al. 1997	Rocky Mountain National Park, CO	1997	Declining
Suzuki et al. 1999	Rocky Mountain National Park and Arapahoe Roosevelt National Forest, CO	1999	Persistent
Barnett & Stohlgren 2001	Grand Teton National Park, WY	2000	Persistent
Repeat Photography			
Manier & Laven 2002	Western Slope, Rocky Mountains	1896-1995	Increased
Elliot & Baker 2004	San Juan Mountains, CO	1875-2002	Increasing
Zier & Baker 2006	San Juan Mountains, CO	1871-2004	Increasing
Long-term Resampling of Plots			
Crawford et al. 1998	Crested Butte, CO	1964-1994	Persistent
Kay 2001	Greater Yellowstone Ecosystem, WY	1934-1996	Persistent
Smith & Smith 2005	Uncompahgre Plateau, CO	1979-1998	Declining
Cover Map and Aerial Photo Comparison			
Bartos & Campbell 1998	Utah (statewide / National Forests)	1902-1995	Declining
Kulakowski et al. 2004	Grand Mesa Area, CO	1898-1998	Increasing
Di Orio et al. 2005	South Warner Mountains, CA	1946-1994	Declining
Kulakowski et al. 2006	Flat Tops, CO	1898-1998	Persistent
Models of Forest Dynamics			
Gallant et al. 2003	Beaver Creek, ID	1856-1996	Declining
Rehfeldt et al. 2009	Western US	2000-2090	Declining (prediction)

Specific Questions/Hypotheses

1) What changes occurred to aspen
   - On the landscape scale, **aspen have decreased** in density and basal area over the past 40 years, with high local variability.
2) Is there a pattern
   - The extent of as **evident decline**
   - Shifts in commu

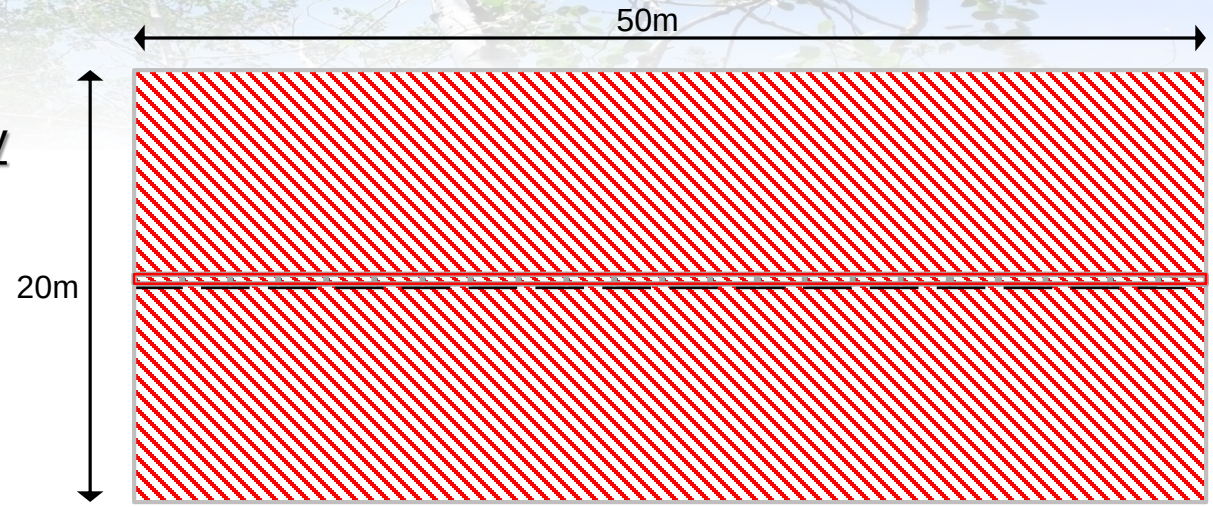


Sources: Martin Beniston, Mountain environments in changing climates, Routledge, London, 1994; Climate change 1995, Impacts, adaptations and migration of climate change, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change (IPCC), UNEP and WMO, Cambridge press university, 1996.

3) How are aspen responding in growth and reproduction to the beetle outbreak?
   - Aspen are allocating resources to stem growth rather than suckers following loss of competition with pine mortality

305 Whittaker Plots

Overstory	Understory
0.1 ha	1 m^2 (25 sub-plots)

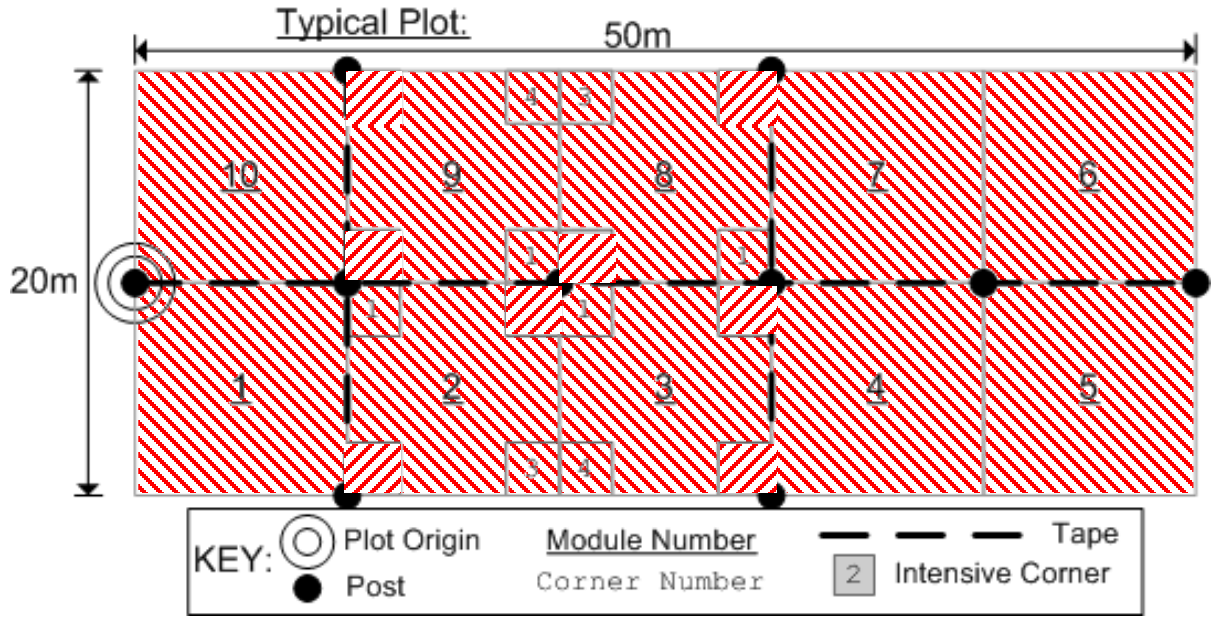


Whitaker Plot (Peet)

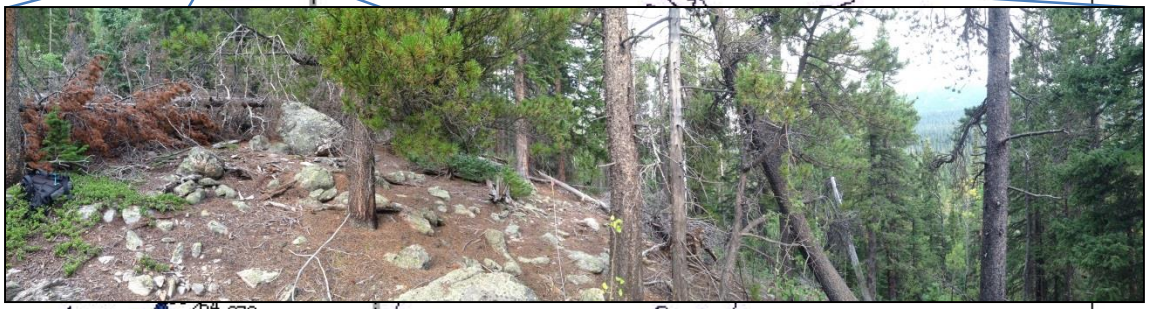
89 Plots that contained *any* aspen

Overstory	Understory
0.1 ha	1 m^2 (8 sub-plots)

Community



CVS Plot (Bretfeld)



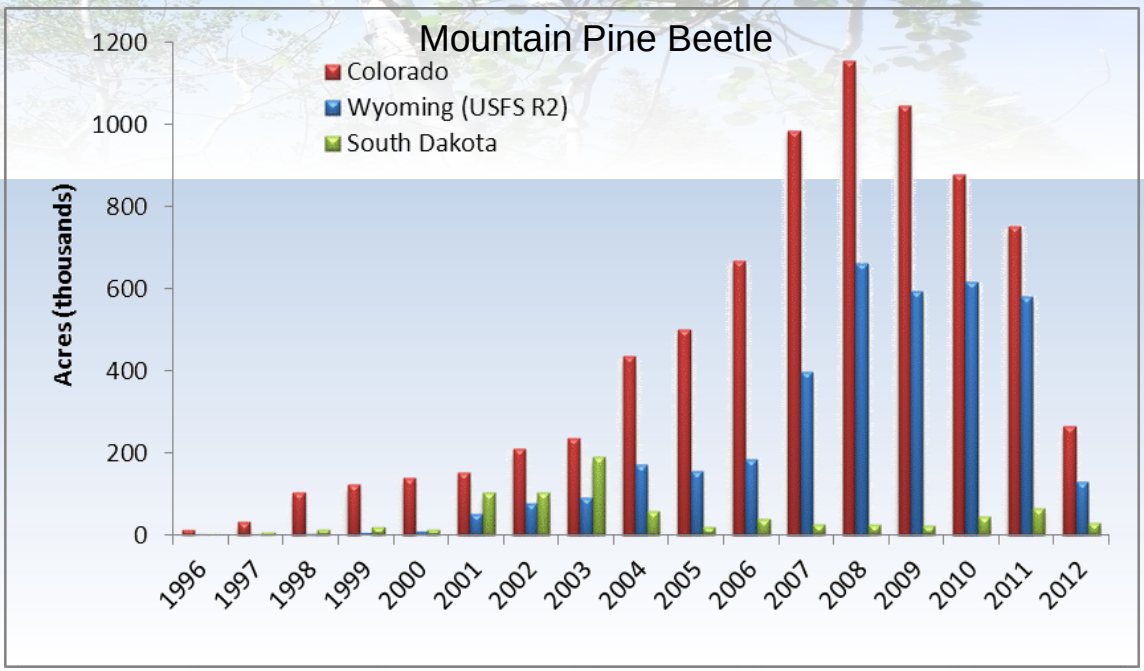
Estes Park

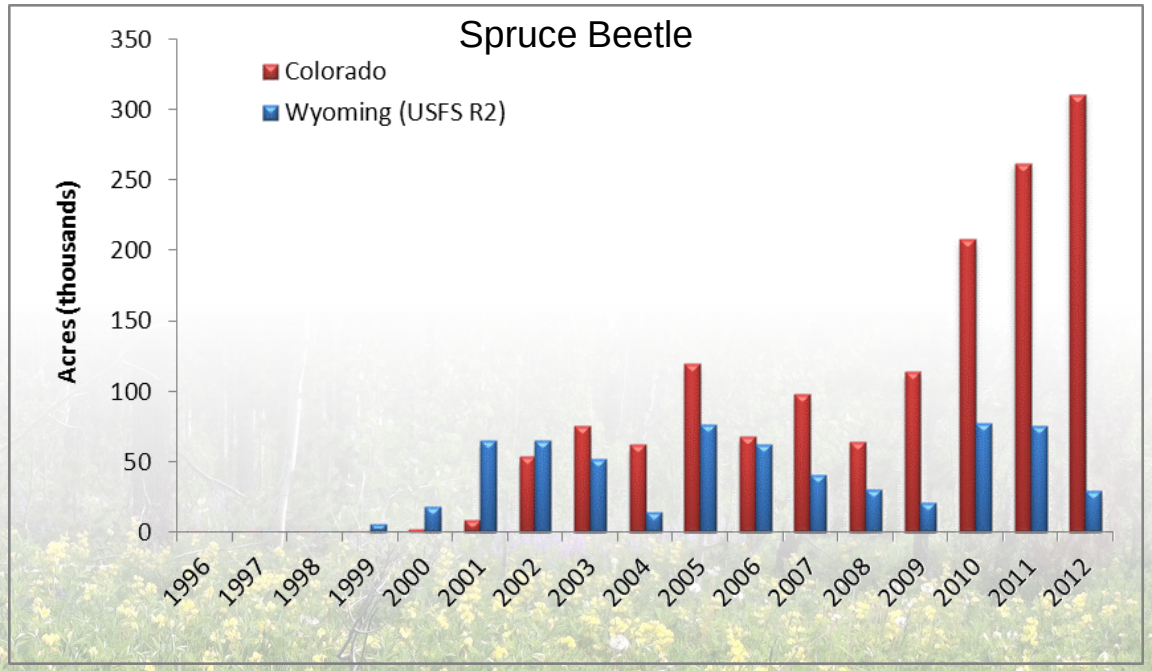
Meters

Thank goodness for global warming!

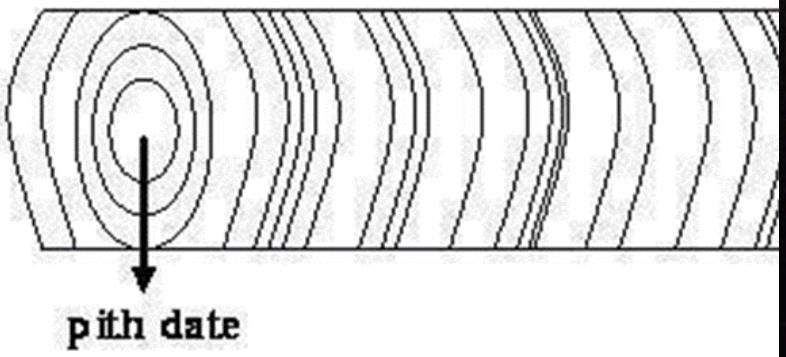
"Research that focuses specifically on effects of MPB-caused forest structure changes on aspen suckering, recruitment, and overstory health, and the potential for browsing and climate to interact with these effects, is needed to inform our understanding of how MPB-caused mortality will affect aspen in western North America."

(Pelz & Smith 2013)





Can dendrochronology help us answer questions about aspen response to disturbances?



Three stand types:

- Beetle-killed
- Mixed healthy
- Aspen only

159 cores

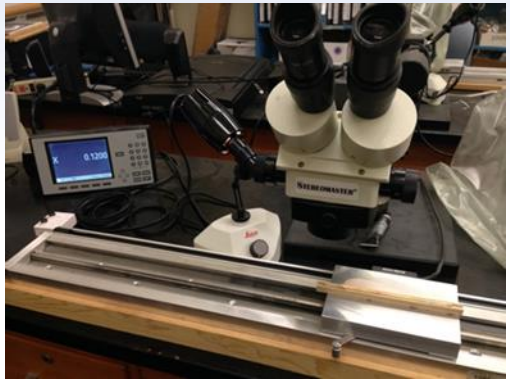


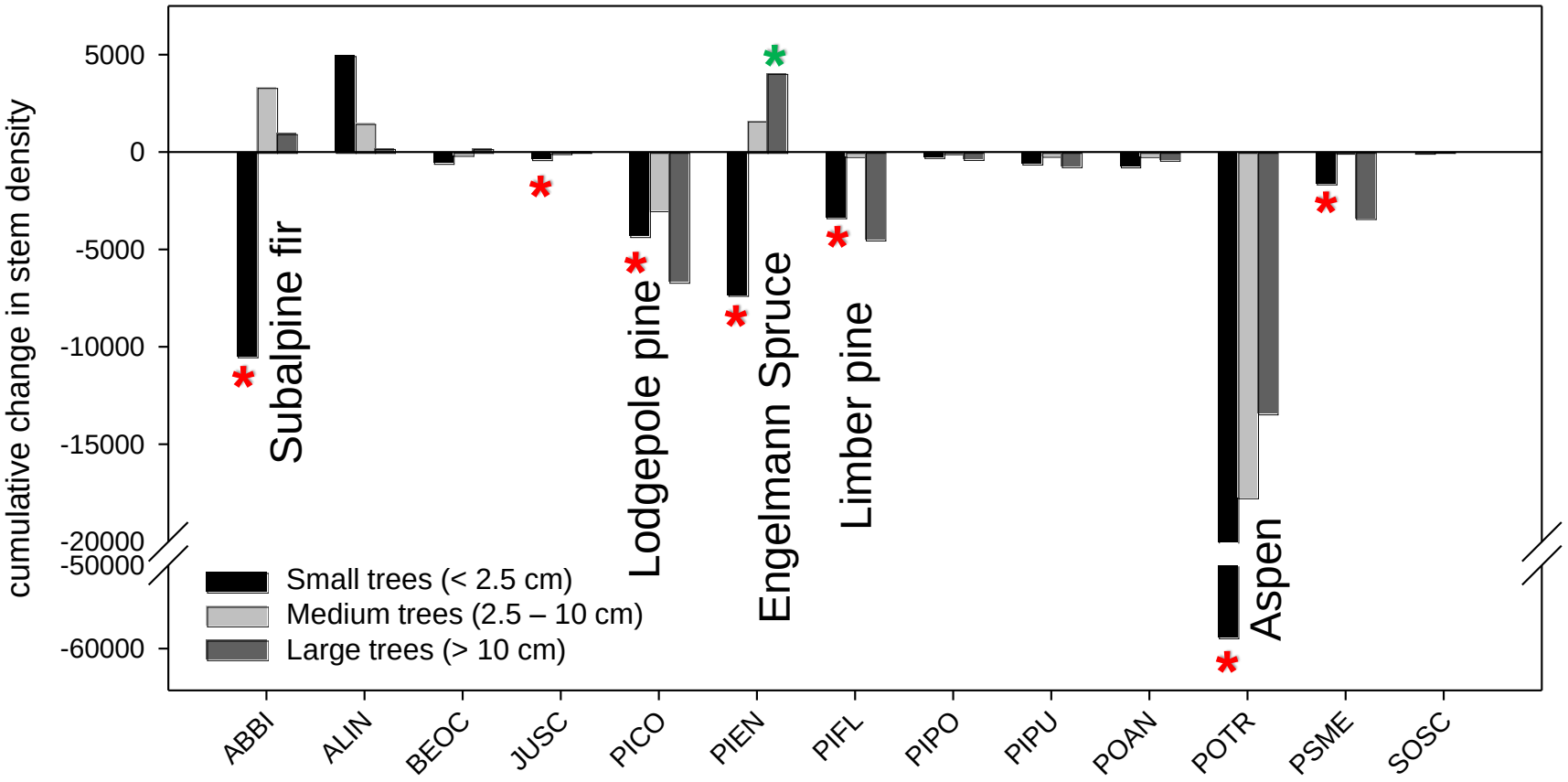
Table 1: Sampling depth, averages and standard deviations of aspen diameters at breast height, and comparison of averages of abiotic factors per treatment; Fraser Experimental Forest.

	Sampling depth			Abiotics			Diameter [cm]	
Type	Plots	Trees	Cores	Elev. [m]	Aspect [°]	Slope [°]	Average	STDev
Beetle	8	39	76	2891	188.1	23.6	17.4	5.0
Mixed	7	33	62	2811	185.0	11.9	31.9	7.9
Aspen	2	10	19	2817	191.5	20.5	34.4	7.1

RESULTS

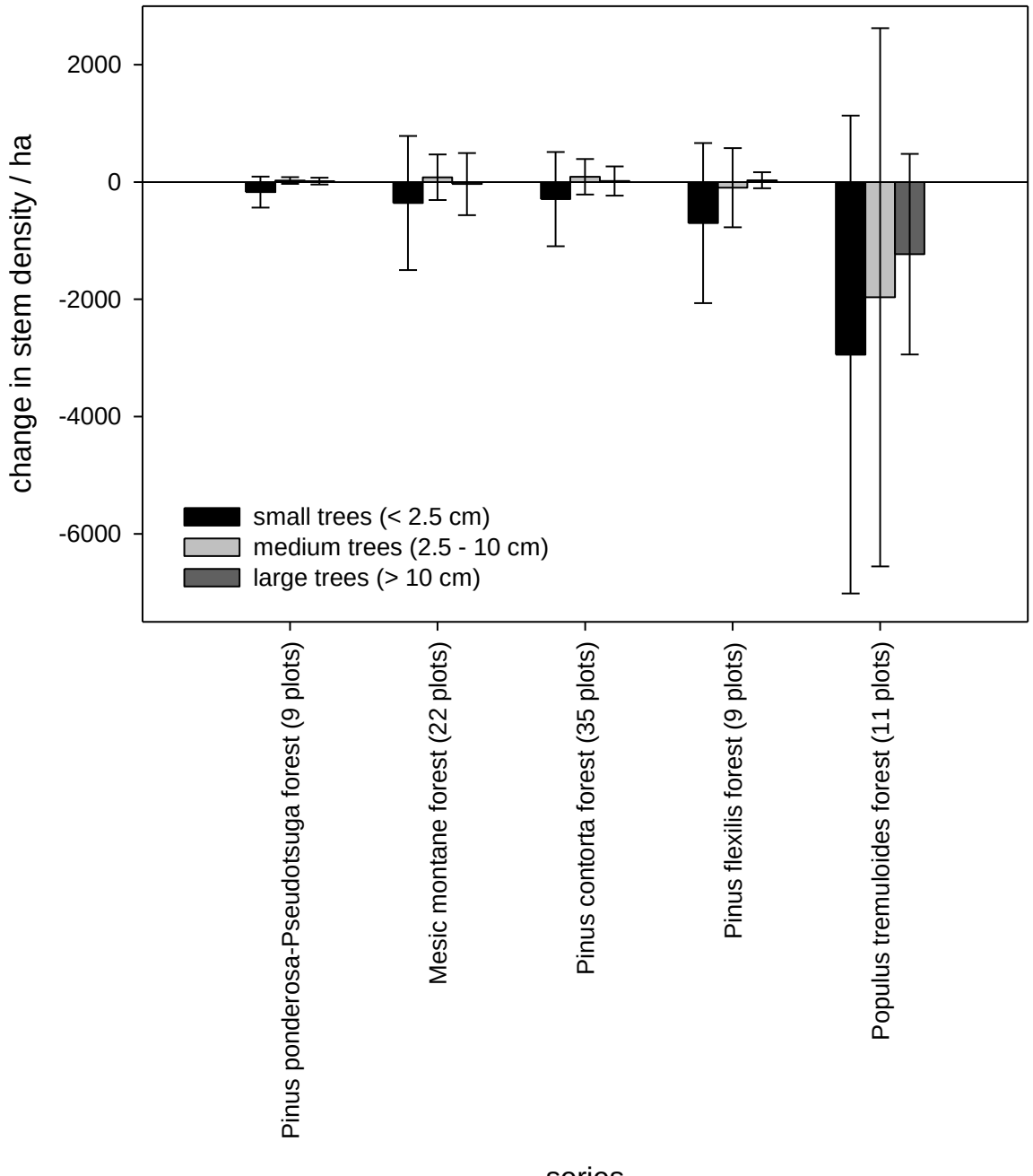
Density

(Landscape Scale, n=89)



Aspen no longer present in 22 of 89 (25%) plots in any stratum.

- no apparent pattern
- 13 of 18 community types



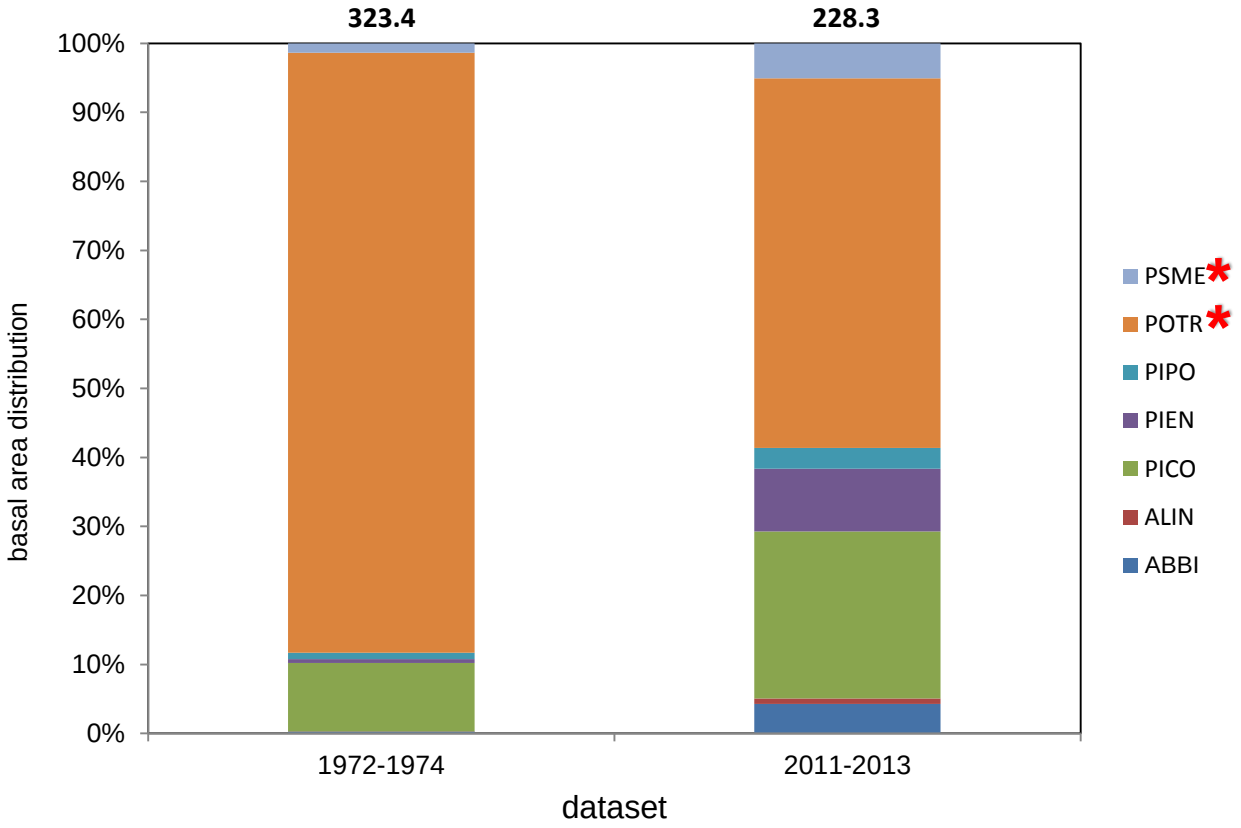
Populus tremuloides Density

(per series)

Decrease in aspen restricted to previously aspen-dominated stands; most were at higher elevations.

Basal Area Distribution

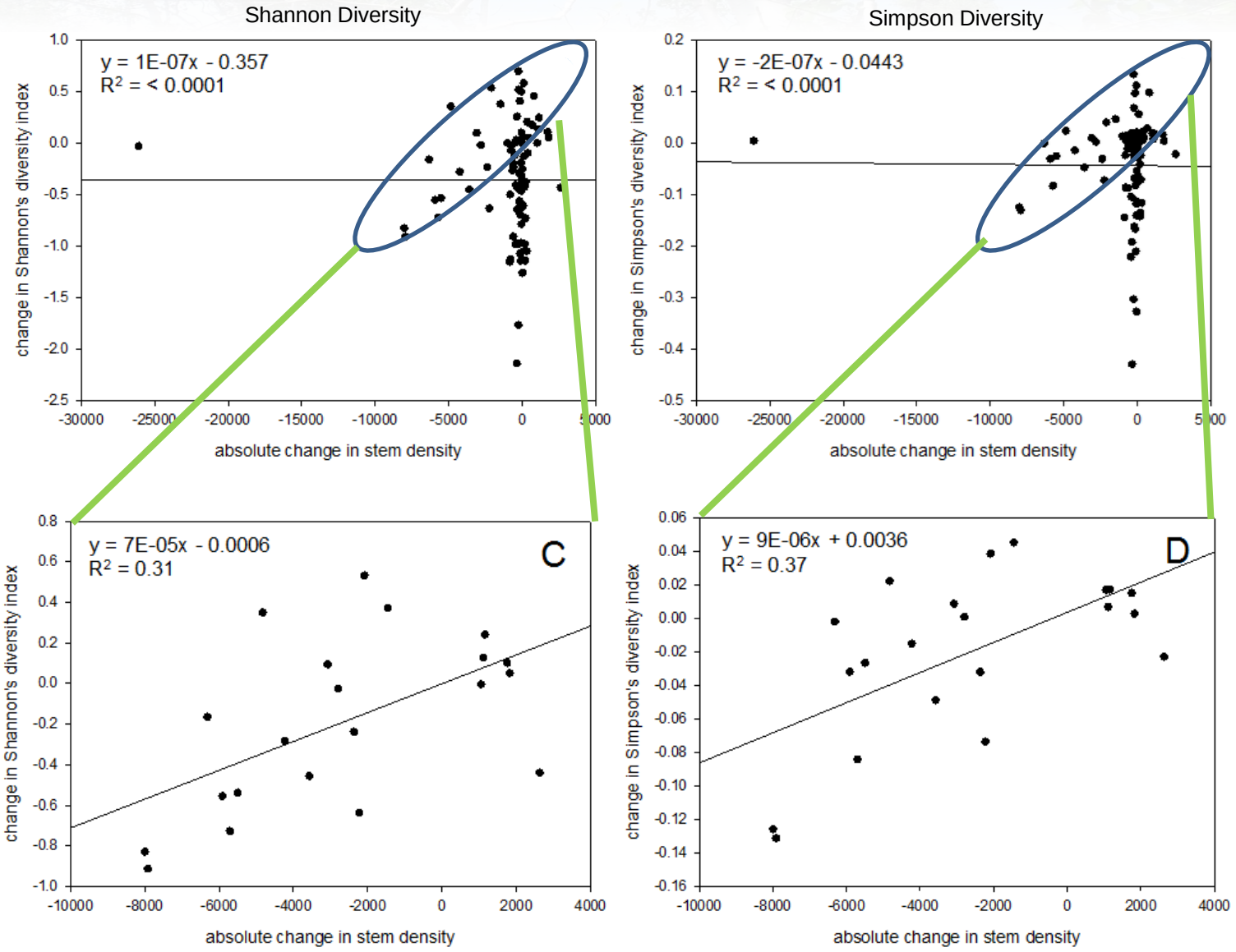
(*Populus tremuloides* Series, n=11)



Data show a typical succession from aspen to conifers.

Density-Diversity Correlation

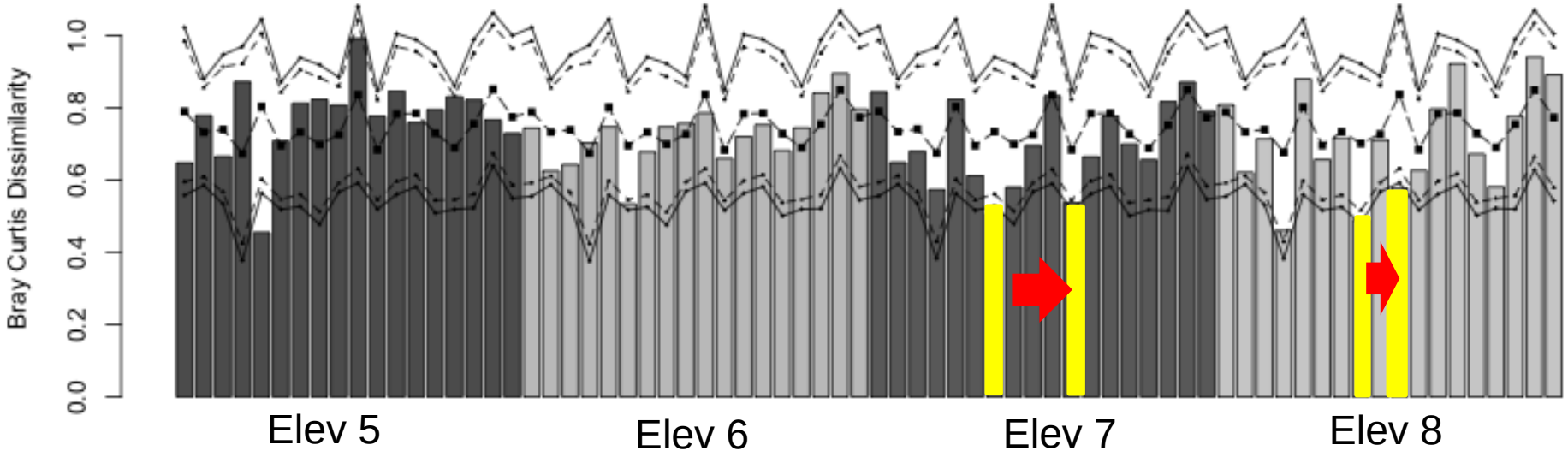
(1000 stems cutoff)



Distribution Shifts: Permutation Analysis

(Landscape Scale, n=89)

Are 1973 communities of elevation x for similar to 2012 communities of elevation x, or x+1, or x+2, or x+3, etc.?



- Shift in elevation from elevation 2636m to 2658m, ~120 m
- Shift in elevation from 2668m to 2728m; ~ 80 m
- Shifts almost **entirely on NE-facing slopes**

69 m over a **30 year period** in southern Californian's Santa Rosa Mountains (Kelly and Goulden 2008)

29 meters per decade of 171 forest plant species throughout Western Europe (Lenoir et al. 2008)

So what about aspen response to the beetle epidemic?

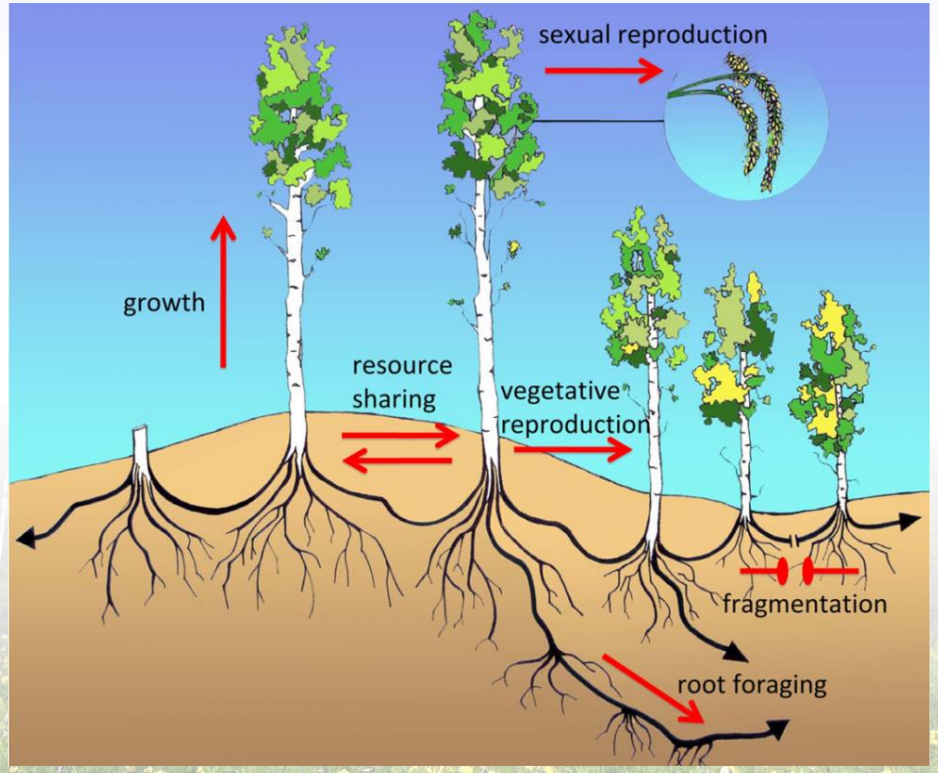
Aspen …

… is a clonal species.

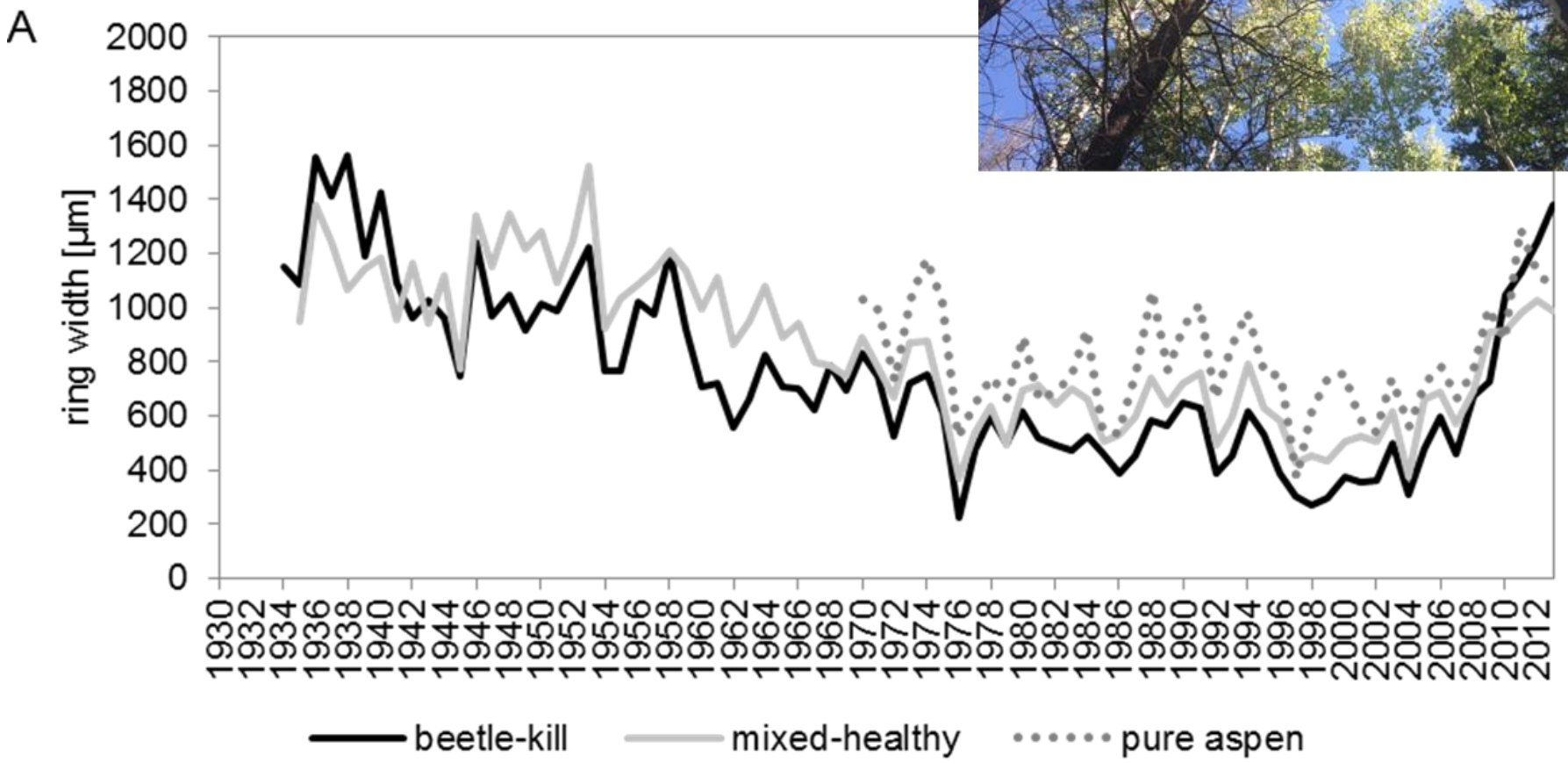
… stems depend strongly on the parent root system for years.

… has the capability to share resources through the parent root system.

… aspen has a choice for resource allocation (stem growth or suckers?).



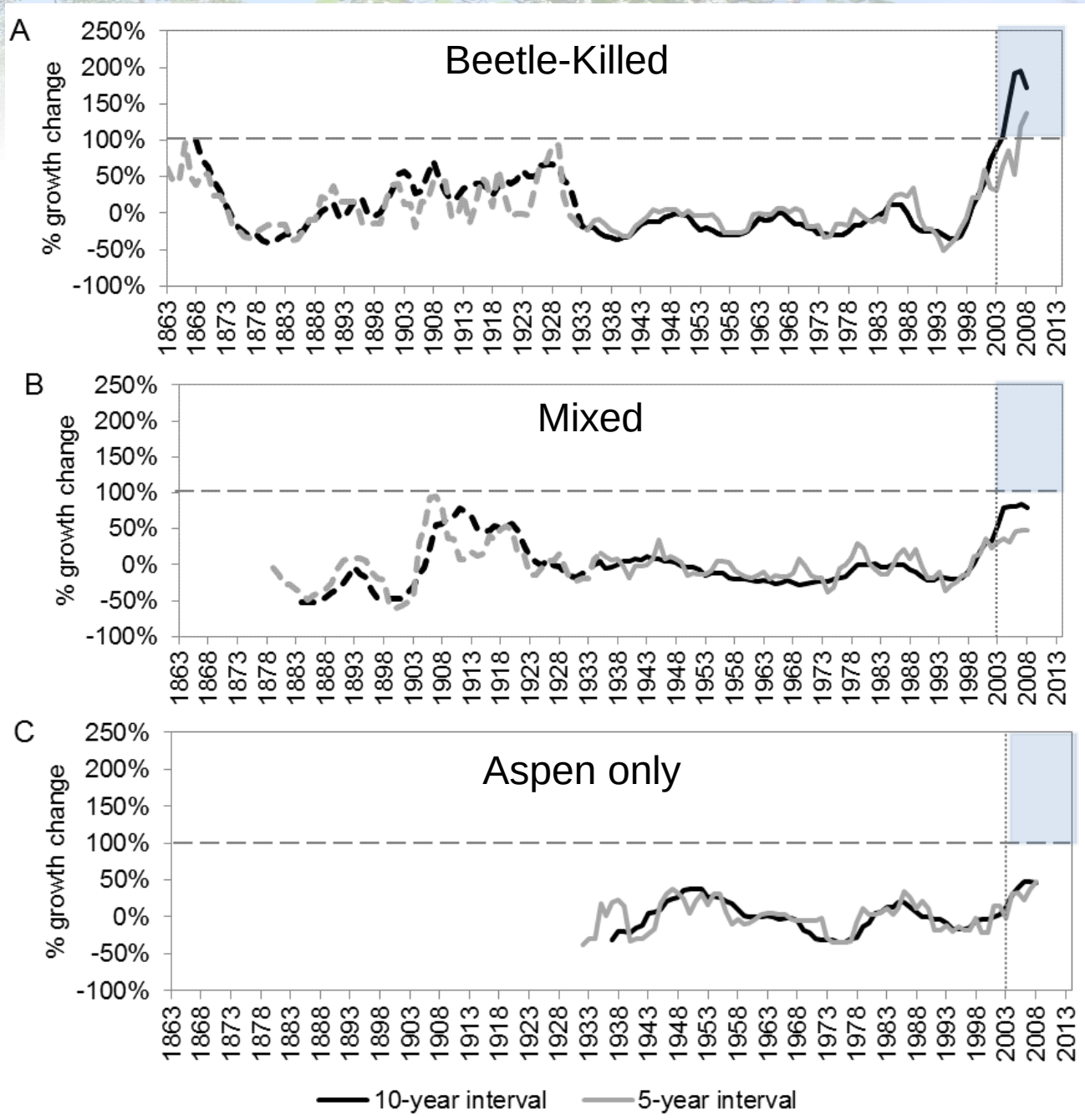
Aspen Radial Growth



- Growth slightly better in mixed healthy until beetle outbreak
- Generally growth peaks and troughs match

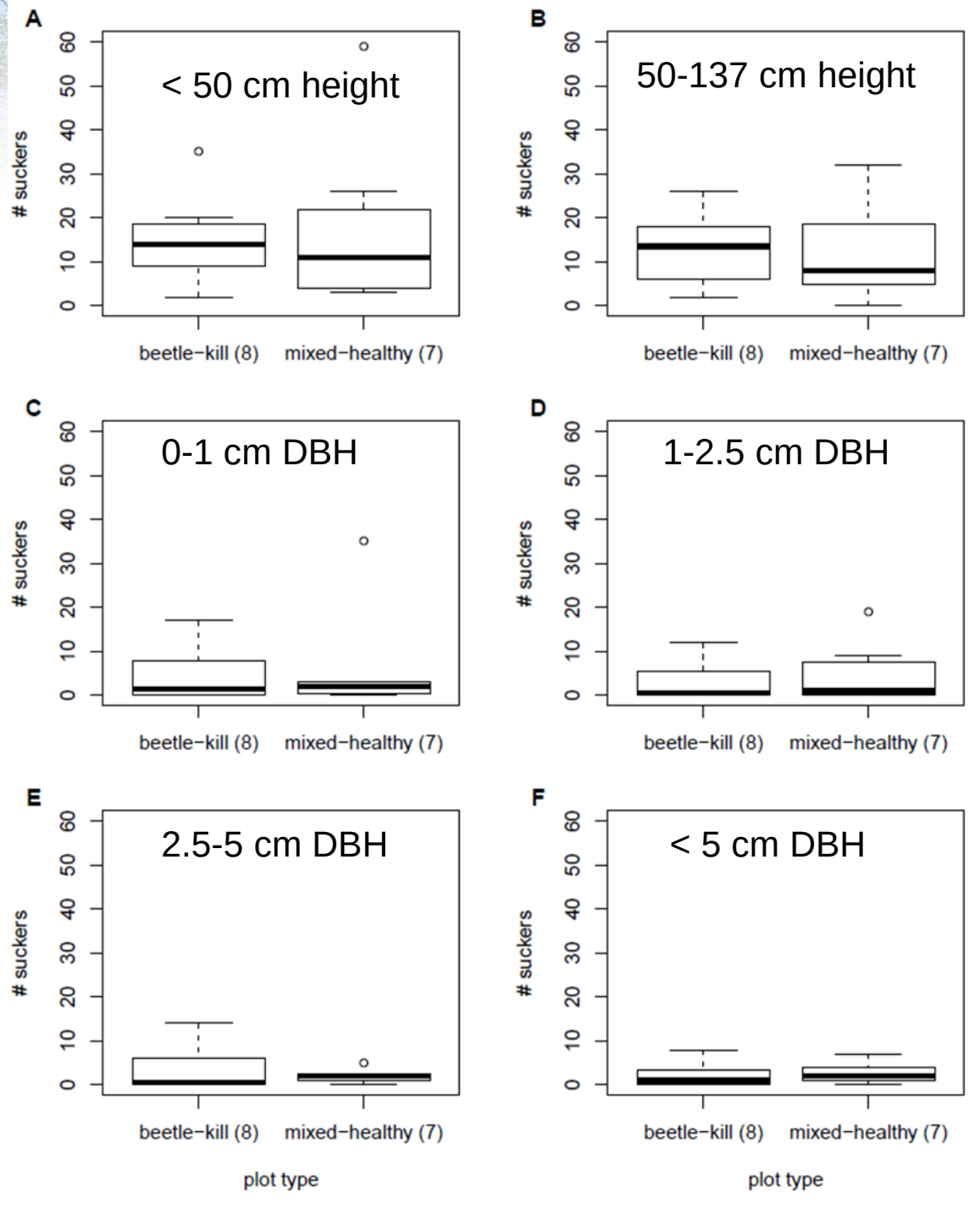
Aspen Radial Growth

Release significant ONLY for beetle-killed stands



Aspen Sucker Regeneration

No difference in suckering between treatments for any size class



Take-Home Messages

- **Aspen** did not decrease significantly on the landscape scale in Rocky Mountain National Park, but did **decrease significantly in forests previously dominated by aspen**.
- Where aspen stem density has changed considerably, **changes in understory vegetation correlate** with these changes.
- Strongest **shifts in vegetation communities** at higher elevations and in areas affected by bark beetles.
- Aspen responded through **stem growth rather than suckering** following beetle kill; opposite of fire response.

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McGregor Ranch

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